The combining of two hobbies creates an organization that is both unique and helpful

BY ALF WILSON, W6NIF

If you're a private pilot and a licensed ham you've no doubt heard of the Happy Flyers. For you non-flyers, I'll explain: it's an international organization that has developed over the past few years under the dedicated leadership and work of Hart Postlethwaite, WB6CQW, who is the International Commander, with headquarters in Belmont, California, near San Francisco.

The Happy Flyers use the amateur vhf bands for providing public-service work through their expertise in using vhf radio direction-finding techniques. Some of the public-service work includes a) saving human lives through locating downed aircraft; b) locating jammers, who delight in obstructing legitimate communications in the amateur vhf bands; and c) providing vhf radio links, for use by paramedics, through the amateur repeater system.

In this article I've outlined some of the work done by the Happy Flyers, although the article by no means covers all of their activities. The material has been taken from the many publications produced by the Happy Flyers and from interviews with WB6CQW; his wife, Janie, WB6ODQ (who is really responsible for it all); and Paul Hower, WA6GDC, who is the Happy Flyers International Vice Commander.

The material is presented for those with a desire to increase their knowledge of radio direction finding techniques using simple equipment at amateur very-high frequencies (144 and 220 MHz).

RDF demonstration flights are provided free of charge by the Happy Flyers. Here's Hart, WB6CQW, making preflight checks of equipment.

How it started

The Happy Flyers (*Happy* derives from *Hams and Pilots Piloting and Yakking*) had a modest beginning in the San Francisco, California, Bay area several years ago. During a QSO between Janie Postlethwaite, WB6ODQ; Bill Cryer, W6RCC; and Ben Autry, K6LHR, they decided to form a group of radio amateurs and pilots for occasional picnic-lunch social fly-ins. At that time, Hart Postlethwaite, WB6CQW, Janie's husband, didn't know anything about

flying. However, Hart, at the urging of the others, obtained his pilot's license and became a member of the group. And so the Happy Flyers organization was born.

How it developed

As the organization grew, members felt that something more than social fly-ins was needed to keep the group growing. What about public service? How could this group of hams, which consisted of licensed pilots and licensed radio amateurs, best serve the community? What were the problems that could be resolved by such an organization?

Three immediate problems were apparent. The proliferation of jammers (those who cause malicious interference on the amateur vhf bands) had become quite serious in the San Francisco area. The locating of downed aircraft and saving lives needed some improvement. A third area of concern, that of alerting paramedics through amateur two-meter repeaters, would improve response time to emergencies. The Happy Flyers have responded to these needs through implementation of their electronic knowhow and dedication to public service.

A jammer is apprehended through the efforts of the Happy Flyers. Plane pilot is the Happy Flyers Commander, Squadron 1, Vic Borgnis, WB6EVH. On the ground are (left to right) Andy Memmel, WA6CBN; Hart Postlethwaite, WB6CQW, Happy Flyers International Commander and Electronic Search Coordinator for the Western States Sheriffs Squadron; the culprit; a policeman from the San Carlos, California, police department; and Roy Everhart, WB6GWQ.

The jammer problem

This category includes not only jammers but also radio-frequency interference (RFI) in general. RFI consists of:

1. Spurious emissions and intermodulation products from transmitters, or both. Causes can include mistuned equipment, component failure, mixing of multiple signals caused by poor equipment design, and interference caused by poor electrical connections.

2. Accidental emissions from radio transmitting equipment caused by shorted key lines, inadvertent closing of microphone switches, children flipping switches, inadequate dummy loads (causing radiation), and an unknown inoperative receiver, to name a few.

3. Intentional interference, which includes two basic categories:

A. Identified transmissions, which are made at a time and in such a manner as to interfere with communications in progress. If the amateur call sign being used is legitimate,

Late News Item — Just as this article was being set in type the Happy Flyers sent us a bulletin about a rescue that their technique and training made possible. The life of a ten-year-old girl was saved after an ordeal of nearly two days.

An airline crew reported hearing the signal from the Emergency Locator Transmitter (ELT) on the second day after a light plane was reported missing. The San Diego Sheriffs Office dispatched Grady Gaylord and Lee Gillard to seek out the ELT site. Both Gaylord and Gillard had received training in the search methods developed by the Happy Flyers.

Heavy cloud cover forced them to fly above 12500 feet, but they obtained a fix on the location within three minutes of first contact, and with an accuracy of better than 1/8 mile. They descended below the clouds to obtain another fix on the crash site. Working with a second plane above, they guided a rescue helicopter to the wreckage and the injured girl.

The girl, Michelle Robson, was thrown from the plane, and spent 42 hours in the rain of heavy thunderstorms that hampered earlier searchers looking for the plane. Her grandparents were killed in the crash. To Gaylord, Gillard, and the Happy Flyers, a much deserved "well done."

View of amateur equipment mounted on the floor of W6RCC's Bonanza airplane. W6RCC, Bill Cryer, is one of the co-founders of the Happy Flyers.

and the amateur is aware of the interference being caused, such action is a violation and is a matter to be resolved by the FCC. If the call sign is not legitimate (a bogus call sign), then a means must be used to search and locate the illegal station. Radio direction finding (RDF) is a potent weapon for these cases. RDF at vhf has been developed to a high degree of proficiency by the Happy Flyers. The methods and techniques are described later in this article.

Bogus call signs are sometimes used by licensed amateurs as a coverup. Such call signs are also used by unlicensed operators (bootleggers) and jammers (often with stolen radios).

B. Unidentified illegal transmissions, which may include a dead carrier, noise, incessant button pushing, music, or just about anything you could think of to disrupt legitimate amateur communications. The people causing this type of RFI are the jammers. The Happy Flyers, using vhf RDF equipment designed and operated by members, have been able to locate jammers with a remarkable degree of success.

The RDF techniques for locating jammers have also been used by the Happy Flyers for locating stolen radios and downed aircraft. The operation of the RDF equipment requires some degree of expertise, which can be obtained through the many publications offered by the Happy Flyers. Techniques vary for locating signals by air and on the ground, but the general idea is the same for both. The equipment needed for RDF work at vhf is quite reasonable in cost and can be readily adapted to your vhf gear. A complete set of instructions on how to build and use the equipment is available together with other useful information for those interested.*

*A self-addressed stamped envelope to Hart Postlethwaite, WB6CQW, International Commander, Happy Flyers, 1811 Hillman Avenue, Burbank, California 94002, will bring much useful information on RDF techniques developed over the past few years.

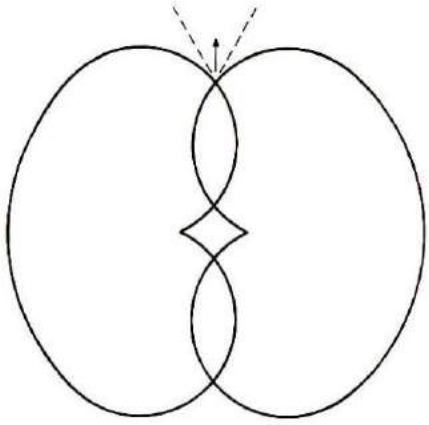


Fig. 2. Response of the switched-cardioid antenna, phase-sensitive RDF system developed by the Happy Flyers. A 90-degree delay line is switched with the antennas, which results in the overlapping cardioid pattern.

RDF techniques — location of downed aircraft

Many thousands of private aircraft occupy air space in the United States. A law passed by Congress in 1974 requires all

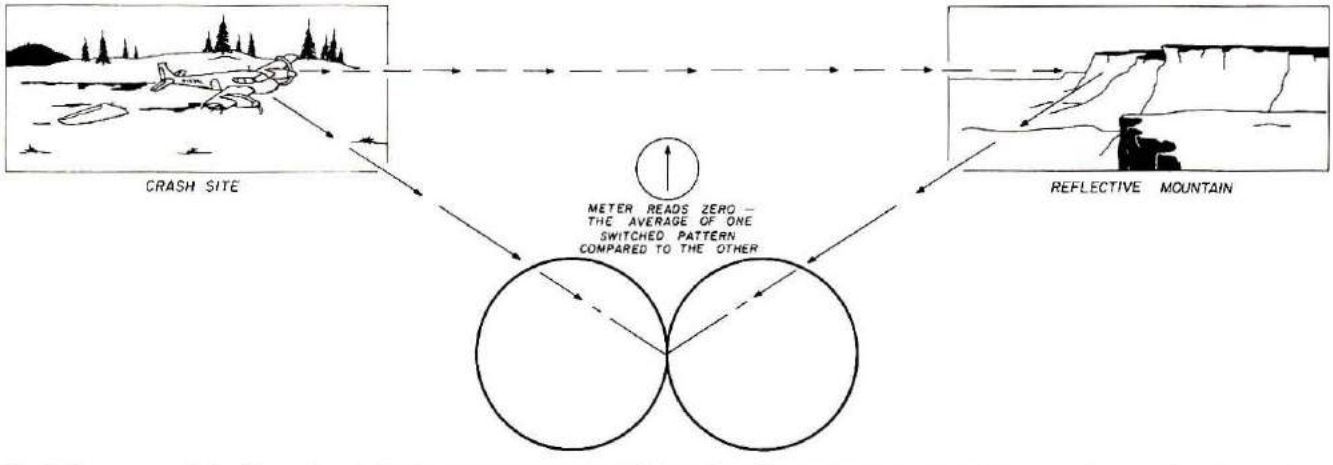


Fig. 1. Response of the figure-8 switched antenna-averaging RDF system. Two antennas, spaced one-quarter wavelength apart, are electronically switched back and forth while receiving. System does not discriminate between true and reflected signals.

piston-engine airplanes operating in this country to contain an emergency locator transmitter (ELT). The ELT is a self-powered radio transmitter designed to become activated on impact, as during a crash situation. The ELT emits a signal on 121.5 MHz, which is one of the international emergency frequencies monitored by the Federal Aviation Administration (FAA), the Civil Air Patrol (CAP), and others.

The idea is a good one, except that problems exist involving electronic know-how in *using* DF facilities for finding downed aircraft within a minimum of time — lives may be at stake in a crash situation, and time is important. The usual tracking procedure, which is employed by the Civil Air Patrol (CAP) in California, for example, is to fly a so-called grid pattern over the suspected crash site while following the ELT signal with RDF equipment.

The grid-pattern technique has generally resulted in a very low degree of success in rapidly locating downed aircraft. The San Francisco Happy Flyers squadron, led by WB6CQW, decided to try to improve the low success rate of locating ELT transmissions quickly by adapting the commercial equipment used by Government search and rescue (SAR) organizations to the two-meter amateur fm band. The advantage offered by two-meter repeater stations as "geometric levers" for extending communications range was extremely significant in the success of this project.

Inside a Happy Flyers' airplane showing, lower right, a Drake TR22 with GLB, Heathkit digital clock, touchtone for autopatch, rotary dial and silent monitor, tone-burst encoder, and subaudible dial tone. The installation is in Hart's Cessna 182.

Airborne RDF — how it works

A comprehensive explanation of airborne RDF techniques used at vhf is available from WB6CQW, as mentioned previously. Here I'll present some of the highlights of the techniques developed by the Happy Flyers to acquaint you with the work that has been done to date.

Automatic direction finders. The automatic direction finder (ADF) is common on airplanes and is used for navigation on the low frequencies. ADF is used on many of the CAP search missions in type C130 airplanes. Happy Flyers originally planned to develop an ADF for ELT search and jammer hunting but abandoned the ADF principle in favor of the present scheme after finding that conventional ADF would not work reliably at vhf because of propagation phenomena and signal reflections.

ADF automatically points a relative bearing to the *strongest* signal source to which the receiver is tuned. This idea works well at the lower frequencies (below 500

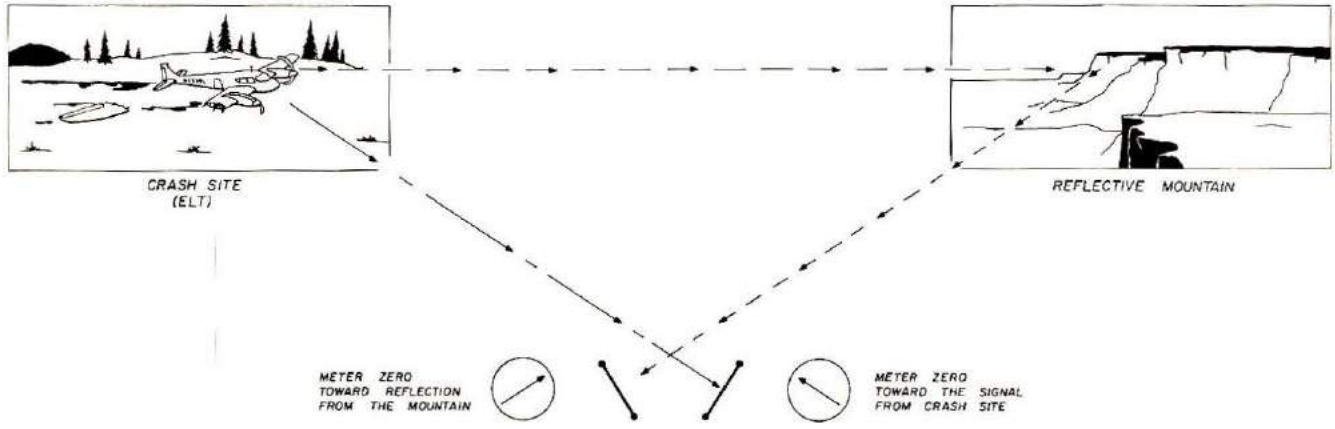


Fig. 3. Example of how the switched-cardioid RDF system responds to reflected and direct signals from an ELT. Each antenna is turned toward each zero indication on the meter. With practice, it's possible to distinguish between the reflected and direct signal.

Bill Cryer, W6RCC, at the controls in his Bonanza airplane. Equipment includes low-band and vhf radios. A longwire antenna can be extended from the back of the airplane in flight. An ICOM 230 radio is used for vhf.

kHz), but at the frequencies we are interested in, namely around 145 MHz, reflections of the signal from objects such as mountains and buildings cause problems to the search operator trying to find the signal source. For example, if an airplane is at a point midway in signal strength between a reflection and the true signal, ADF will search back and forth, attempting to indicate the strongest signal. At vhf, the *reflection* can be the *strongest* signal arriving at a given point. The ADF principle is therefore unreliable for vhf cross-bearing triangulation and can cause wasted time while the search operator follows reflections. ADF is excellent, however, when used for navigation in the frequency range of its design.

Beam and loop antennas. These antennas are sometimes used for direction finding with a receiver that has a signal-strength meter. Some operators rotate these antennas until the signal-strength meter reads maximum; others use the minimum reading. (Maximum readings are usually superior on extremely weak signals; nulls are superior on stronger signals.)

These antennas, when used for direction finding, also suffer from the problems of reflections and multipath at vhf and uhf. (Multipath is a phenomenon you've no doubt experienced with TV signals radiating from buildings in your vicinity that cause "ghost" images on the TV screen. Multipath transmissions can cause all kinds of problems to the fellow trying to locate a signal source.)

If a direct signal and a reflection are near each other, the field-strength meter might average the two signals. On the plus side, however, gain antennas (beams) will allow you to acquire starting directions on signals that are too weak to be heard on switched-antenna arrays. (Loop antennas are generally too insensitive for this application and are not considered.)

Field-strength devices. These instruments serve a purpose, but they are of limited use for serious work in locating signal sources. For example, Hart, WB6CQW, has used a surplus military field-strength unit, which is tunable between 100-160 MHz, to locate the exact signal plane within a field of many reflected signals. The unit works well when trying to locate jammers at close range — say within one city block. The S-meter on a handheld transceiver can also be used in the same fashion. Again, this scheme is good only at close range. (The equipment should be reasonably well shielded.)

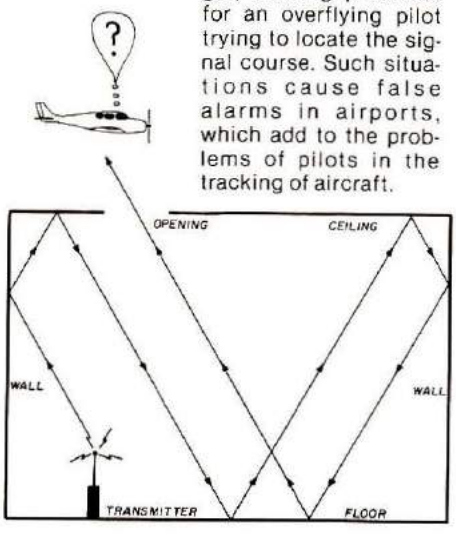
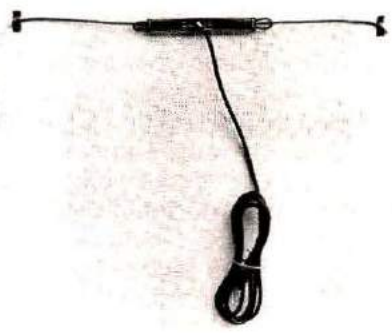


Fig. 4. An example of multipath signals radiating from an ELT inside an airplane hangar. Signals bounce off walls, floor, and sides of the hangar, causing problems for an overflying pilot trying to locate the signal course. Such situations cause false alarms in airports, which add to the problems of pilots in the tracking of aircraft.



A paste-on DF antenna that can be fastened to an airplane windshield makes an easy and effective temporary installation. Note phasing line in the center.

Switched antenna arrays. Systems using these antennas can be divided into three categories:

1. Multielement electronically rotated arrays (such as the Adcock system).
2. The figure-8 pattern averaging RDF array.
3. The switched-cardioid, phase-sensitive, RDF array.

The last-mentioned system is that used by the Happy Flyers in their RDF work, after extensive experiments and development of the associated hardware.

The Adcock array is extremely expensive for use in amateur work. Commercially available equipment runs between about $2000 and $8500. Briefly, the system electronically switches antennas between received signals, and the resolved data is displayed on a cathode-ray tube. The system will indicate various instantaneous directions to rf sources; the actual signal source is indicated by a line, displayed on the CRT, that is the most

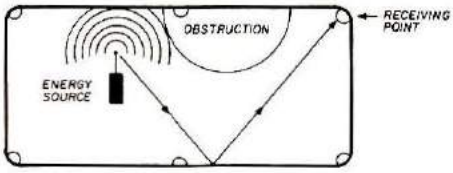


Fig. 5. An example of the "pool-table" effect on reflected signals. The angle of incidence always equals the angle of reflection. Here the signal passes around the obstruction by reflecting from the side of the table to the receiving point — an example of single-source reflection. The RDF gear will indicate *toward the reflection* point rather than toward the rf source.

consistently shown magnetic bearing to the source. The same general information given by these expensive units is available from the switched-cardioid RDF units designed by the Happy Flyers.

The figure-8 system uses left-right indicators to guide the pilot during a search operation. Two antennas, spaced about one-quarter wavelength apart, are electronically switched back and forth while receiving signals. This action results in a figure-8 pattern, as shown in **Fig. 1**. Most systems of this type compare data obtained during the time each antenna is switched on. The difference is displayed on a zero-center meter. If the meter indicates left, you turn in that direction; if the meter indicates in the center, you are supposed to be pointing at the signal source. However, if you have two sources of rf, each of which is 45 degrees to your heading and of about equal strength (such as a reflection and a true signal from a crash site), the unit will indicate *straight ahead*. This

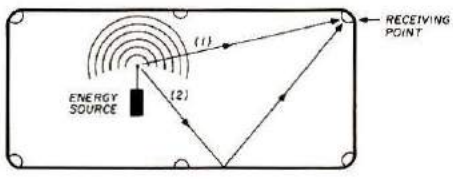


Fig. 6. An example of two-source multipath. The obstruction has been removed, and there are two possible paths over which the signal can reach the receiving point (RDF gear). The problem now becomes much more difficult in locating the true direction of the signal source.

action occurs because there is little or no difference between the information arriving from both sources (*i.e.*, true and reflected signals).

Such a situation can cause tremendous bearing errors when used for triangulation — that is, when using geometric plotting to determine the true source of the signal. It can also cause you to fly endlessly in circles.

Signal reflections follow scientific laws: the angle of incidence must equal the angle of reflection. As you move, the angle of incidence and reflection will cause a continuous change on the reflection side — including complete signal disappearance at times. This will usually cause a continuing change in indicator needle position, which is not necessarily related to the actual signal source, unless you can get completely away from signal reflections.

The switched-cardioid, phased RDF units are used by the Happy Flyers for search and rescue operations. This system works similarly to the switched figure-8 system, but the difference is in *how the antennas are switched*. A 90-degree delay line is installed in the switching network. When the delay line is switched, two overlapping cardioid patterns occur, as shown in **Fig. 2**. Varying the degree of phase delay will also vary the overlap, which affects system sensitivity and selectivity.

How the phased-antenna system works

The antennas are switched at a rate of about 80-120 times per second. The delay line is also switched, so that two cardioid antenna patterns are produced. The antenna switch-rate chops the audio entering the receiver and establishes a reference (similar to a clock or timing pulse).

Detected audio is fed into the RDF unit, and its phase angle is compared to the reference. The RDF unit looks

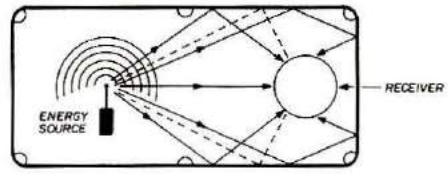


Fig. 7. Multiple-source multipath. This situation would create an extremely difficult tracking problem and one that is more likely than not to occur during an actual ELT search. The problem can be resolved with the proper equipment and techniques.

at the crossover of the switched-cardioid pattern. Any phase difference is indicated by needle deflection. Accuracy is a function of the audio-phase relationship between the antennas. (The distance from the rf source for a variation in signal strength, or amplitude, does not change the accuracy of this equipment.)

Because it looks only at the narrow aperture of the cardioid-pattern crossover slope, the cardioid-system is capable of showing more than one source of signal toward a given location (**Fig. 3**). In the example given for the system using the figure-8 pattern, two signals 45 degrees apart were indicated. This phenomenon can often be seen on the switched-cardioid type RDF units. This needle will vibrate as it goes toward center position instead of deflecting smoothly. Even a disturbed direct-path can be detected with practice.

Front-to-back resolution

Both the switched figure-8 and the switched cardioid RDF systems can distinguish between front readings (*toward*

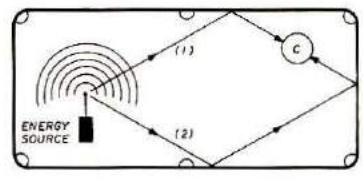


Fig. 8. The cancellation effect caused by two rf paths, in which the signal arrives at the same point from opposite directions. Theoretically, they would cancel at point **C**. Actually there could be many points of signal cancellation and addition in a real-world situation.

Hart, WB6CQW, and Larry Reed, W6CTH, beside Hart's Cessna. Larry did the copy work for the free film shows given by the Happy Flyers for public relations seminars across the country.

the source) and back readings (180 degrees *from* the source). By turning toward the needle, you'll always be facing the target when the needle comes to zero. With the switched-cardioid phased system, you'll be facing a source of rf, but not necessarily the correct source. With the figure-8 system you'll be looking at the direction of the *average* rf source.

In summary, when a no-reflection, no-multipath situation exists, both systems will point to the actual rf source. In a multipath situation, the figure-8 system will show the average path; the phase-switched cardioid system will show many paths of the signal, which is indicated by each meter zero you find during a 360-degree turn. With the switched-cardioid system, only the zero reading is a valid bearing in multipath situations.

The multipath problem

You'll notice the emphasis that has been placed on the propagation phenomenon known as multipath. Multipath occurs when a signal reaches a receiver over two or more different paths. Often one path is direct to the receiver and the other arrives as a reflection (as from a mountain, building, or other object). Either signal can be the strongest received, depending on the circumstances of the paths to the receiver.

Usually one bit of signal information arrives at the receiver slightly later or earlier in time. An example is the ghosts often seen on a TV receiver, in which the picture is displaced slightly on the TV screen. In communications receivers, multipath is noticeable as a fuzzy audio reception.

Coping with multipath propagation is extremely important in RDF work — the indicating meter will try to show you the direction of all signals, including the desired signal. And the desired signal isn't necessarily the strongest signal! Consider **Fig. 4**, which illustrates reflected paths from a transmitter located in a building. The signal bounces off walls, floor, and ceiling through a hole in the ceiling to the pilot in the aircraft above. Situations such as this have occurred during the Happy Flyers' airborne ELT search program. In this case the multipath causes false alarms when ELTs have been accidentally actuated in airplanes stored in hangars, for example.

A helpful fact to remember when working with signal reflections is that such signals do not violate the laws of physics: the angle of reflection *must* always equal the angle of incidence. The sketch of **Fig. 5** shows this principle, in what is known as the "pool-table" effect. For simplicity, only one path of energy from the source is shown; however, radio-frequency energy radiates in every direction from a whip antenna. Note that the RDF equipment at the receiving point would indicate toward the reflected point rather than toward the actual source.

By removing the obstruction and showing two rf paths, as in **Fig. 6**, we can illustrate one type of multipath. Signal 1 is the direct signal, and signal 2 is the reflected, or multipath, signal. This phenomenon is known as two-source multipath.

Another form of multipath transmission, which is not uncommon in RFI and jammer hunting in metropolitan areas,

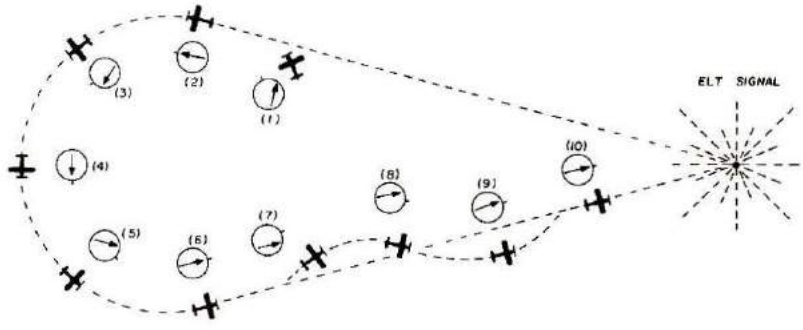


Fig. 9. An example showing the procedure used during normal homing on an ELT signal with no multipath. A 360-degree turn is made from the beginning of signal reception. The procedure is straightforward in this situation, as explained in the text. The meter indications are shown as they would be seen on the panel in the airplane.

is shown in **Fig. 7**. The sketch shows multiple reflections from the energy source, all arriving at the receiver at different times because of path differences. Such a problem can be resolved with proper equipment and techniques.

So far we've illustrated rf paths as if each had no effect on the other. We know this isn't true, because each path interacts with the other. When we use gain antennas, we can arrange them in such a way to take advantage of phase addition and cancellation. **Fig. 8** is an example of multipath transmission that shows the cancellation effect. This is known as two-source cancellation. In this example, two rf paths are shown arriving at the same point (**C**) from opposite directions. In theory the two signals would cancel. However, in the real world, there could be many points of signal cancellation and addition.

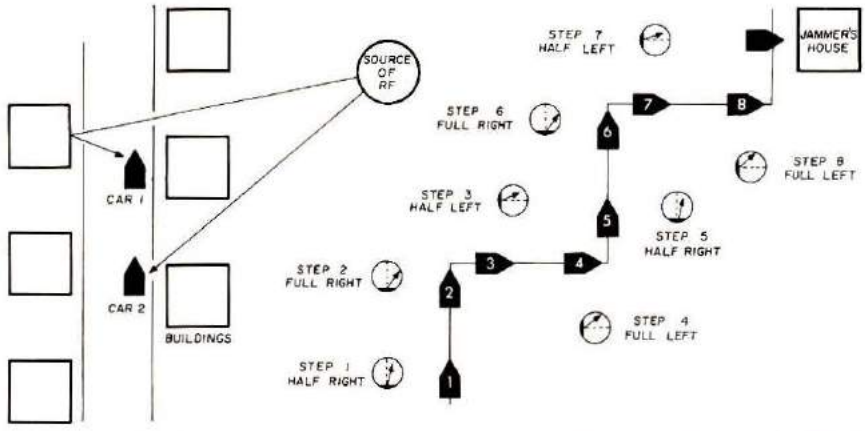


Fig. 11. A method for locating ground-based jammer signals suggested by WA5TRS in Oklahoma. The switched delay line, cardioid antenna system is used in autos. The RDF system only looks at the narrow aperture of the signal crossover, which helps tremendously in resolving multipath problems. A high success rate is claimed for this method.

Procedures for beginning an airborne ELT search

The following procedures for a typical search have been developed by the Happy Flyers for those who are interested in using private airplanes equipped with RDF equipment.

1. Turn on your RDF unit and verify that the indicator needle points in the proper direction. An S-turn is suggested to further verify that the needle passes through zero and indicates the proper direction. (Some dual installations require flipping a switch for meter reversing. Be sure the switch is in the correct position for the radio in use.)

2. Be sure you are *high* enough above surrounding terrain for initial readings. A minimum of 2000 feet (610m) above ground level is recommended for the first reading; 4000 feet (1220m) above ground level is suggested for enroute search in average terrain. In hilly and mountainous areas, much higher altitudes are recommended to minimize the possibility of wasting time following reflections.

3. Start a level, 360-degree turn *away* from the direction of needle indication. This will allow you to check for signals within the entire 360-degree circle without turning the entire distance. Remember that for each signal bearing, there should be a *to* and a *from* zero reading; therefore, any turn more than 180 degrees will show multiple signals in your immediate area.

Normal homing — 360 degrees with no multipath: assuming you receive the direct signal from the ELT, the procedure would be as in **Fig. 9**. In this figure it's assumed that no wind condition exists. Remember that when the needle centers when you turn away from the needle's direction, a *from* bearing is indicated; when turning toward the needle's direction, a *to* bearing is indicated. Always make an S-turn on the zero reading to verify that you're not at a 90-degree null. True bearings will always deflect to both sides of zero on the indicator. Referring to **Fig. 9**, proceed as follows:

1. Needle indicates *right* — a turn to the left should be made.
2. Needle indicates zero, indicating a *from* bearing.
3. Needle indicates maximum *left* deflection (maximum signal strength). This is the 135-degree point.
4. Needle indicates minimum (it could be almost *zero* or slightly left of *zero*). This is the 90-degree point.
5. Needle indicates maximum *left* deflection (maximum signal

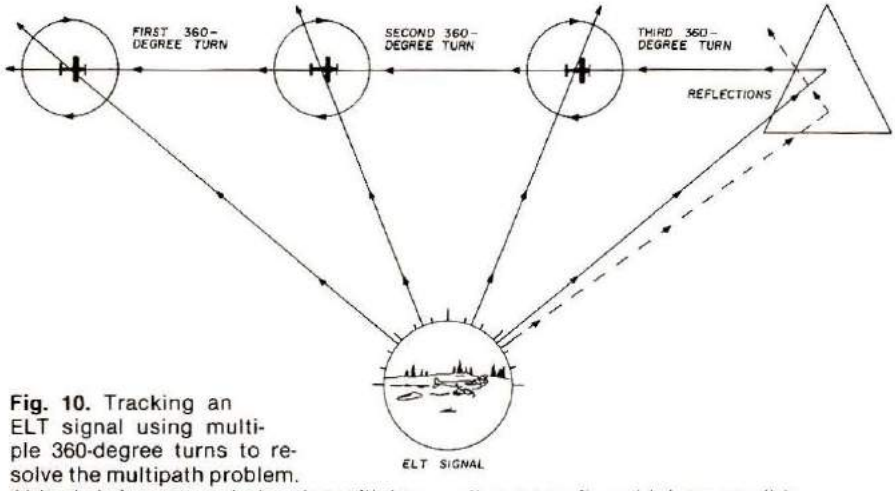


Fig. 10. Tracking an ELT signal using multiple 360-degree turns to resolve the multipath problem. Altitude is important during these flights — pilots try to fly as high as possible.

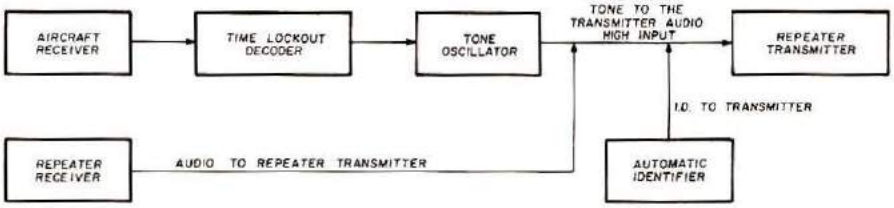


Fig. 12. Block diagram of a tone-alert time-lockout decoder system for amateur repeater stations for participating in search and rescue work.

strength). This is the 45-degree point.

6. Needle indicates *zero* while turning toward needle indication of step **5**. This indicates a *to* bearing.

7. Continue the left turn; indicator needle moves to the right.

8. Make a right turn toward needle indication of step **5**. Needle returns to *zero*.

9. Continue the right turn through zero meter indication. The needle will then indicate *left*.

10. Center the needle and follow it to the target. Keep the needle at zero center. (Note that no wind corrections are indicated for this case.)

Complex plotting situations — multipath and reflections: You'll notice the indications of S-turns after steps **2** and **6** in the example above. (These are the zero points.) After verifying a bearing, establish a course on zero long enough to obtain a magnetic heading. Write down the heading and the bearing (such as: 300 degrees *from*.) Then continue your left turn, as in step **3** above.

In a complex situation you would find more than two zero points. Each suspected zero should be verified by the S-turn procedure and a *solid zero crossing* of the indicator needle. Write down each bearing, as 300 degrees *from*, 240 degrees *to* and 60 degrees *from*, for example.

The logical procedure would be to draw lines on your map in these directions from your location. Choose a line you think to be a logical bearing, and begin a climb enroute on your chosen course. Climb 2000 feet (610m) or so, then repeat the 360-degree procedure. If you obtain only one *to* and one *from* reading, proceed as on normal homing. (Your altitude and location change, or both, will have eliminated the reflection.) If you get another (or more) *to* bearings in addition to the one you're following, plot these bearings on your chart. Extend all lines and compare them with the previous lines. If the lines intersect, then you would home on the most likely course.

Again, *climb* enroute on your chosen course until you're further and higher than the last check point to make a new 360-degree turn. With sufficient altitude and proper geometrically spaced 360-degree checks, you should have at least one intersecting point on your chart.

It's not possible to cover every complex homing situation here; however, if you follow the procedures outlined above, and with logical thinking, you should go far toward solving even the most unusual problem in search procedures for downed aircraft.

As a further aid, **Fig. 10** is presented, which shows 360-degree turns, without showing the S-turn procedures for simplicity. Always use S-turns to verify *to* and *from* bearings, as well as signal nulls.

Ground tracking — an example

Several ground-tracking techniques have been developed by the Happy Flyers, and these are well documented in their publications (available from WB6CQW as mentioned previously). The mode known as "maximum-deflection homing" is described below as one of the more effective tracking schemes for ferreting out jammers.

The method was suggested by Joe Buswell, WA5TRS. It works well when there's little time for triangulation (as with stolen radio searches). Operation in this mode is simple and effective and is also used by the FCC.

Fig. 11 illustrates WA5TRS' suggested method. The

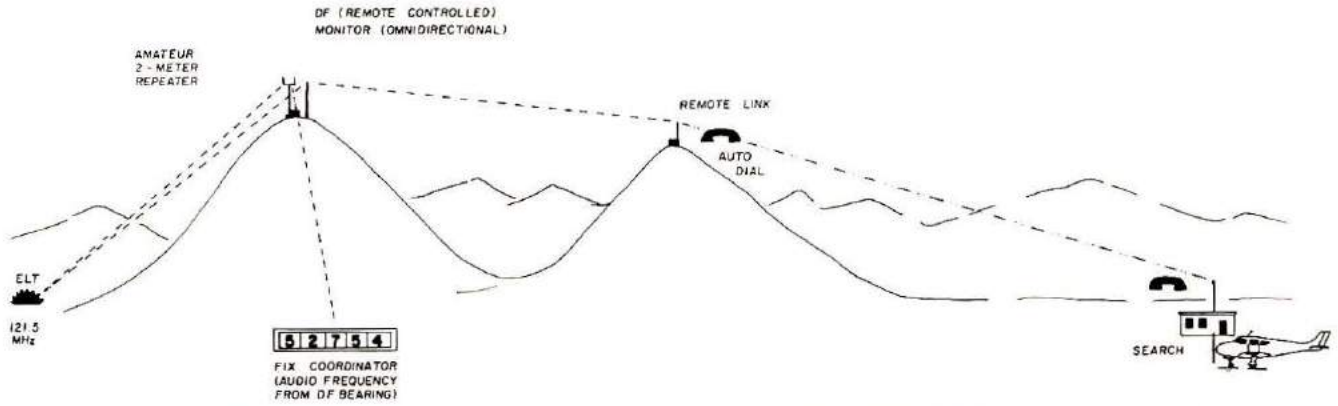


Fig. 13. Typical ELT-repeater scenario showing up-down links between an emergency signal (ELT) and an airborne search team.

switched-cardioid RDF looks only at the narrow aperture of the crossover, as explained previously. The indicator needle will pin somewhere between 15 and 25 degrees per side, depending on the setup used. This means the needle will pin long before the source bearing can become 90 degrees from your heading.

As you drive along with your fixed DF antenna hidden on your car windshield, a jammer comes on. When you first turn on your equipment, the indicator needle indicates to the right about half scale. You continue driving down the street while observing the indicator needle. As you pass between tall buildings and vacant lots, the needle jumps from side-to-side. However, each time the indicator needle swings to the right, it goes a *little more* to the right. Finally, it will always go to the extreme right *when not indicating a reflection.*

You turn right at the next intersection, and the average indication changes to the left side of the meter. You then continue until the meter reads to the extreme left most of the time. Then, a turn to the left moves the meter to the right again. You repeat this operation until you're at the jammer's door. The entire procedure averages about five turns, depending on terrain.

Notice in **Fig. 11** that the signal path to car 1 is reflected, and car 2 is shown receiving the signal over a direct path. It will readily become apparent how this will work as you drive down the street. The method, according to Hart, WB6CQW, hasn't been tried in San Francisco (many hills in the city), but it works well in the Oklahoma flat country.

Repeater monitor programs

Use of the amateur vhf repeaters to monitor emergency traffic for search and rescue (SAR) has been a significant part of the work done by the Happy Flyers. Hart, WB6CQW, and his wife, Janie, WB6ODQ, have made many presentations to repeater groups throughout this country and Canada, describing methods of using repeaters to augment SAR activity. These presentations include slide shows and talks on amateur radio participation in SAR as well as ideas for resolving the problem of interfacing SAR hardware and operating techniques with amateur repeater stations. A comprehensive discussion of the problems of SAR-repeater interface is given in the Happy Flyers' *Repeater Monitor Manual*, which may be obtained by sending a self-addressed, stamped envelope to WB6CQW (address given elsewhere in this article). Here are some of the highlights that make up the SAR-repeater monitor interface.

Andy Memmel, WA6CBN, stands beside his car, which has been fitted with a demountable roof rack containing a pulley system that allows him to change antenna direction and read azimuth bearings from the driver's seat.

The basic idea is to install a receiver that monitors 121.5 MHz (the international emergency frequency) at the repeater site, with appropriate control circuits to alert participating SAR teams. The monitoring equipment, of course, must not interfere with normal repeater traffic.

An essential part of the SAR repeater installation is the time lockout decoder. The purpose of this circuit is to require the presence of the ELT signal (a continuous downswept tone) for a prescribed period before the alarm circuit is activated. The reason for this circuit is that, according to law, all ELTs may be tested during the first five minutes of each hour. Obviously, if an ELT test is made without some kind of lockout system, false alarms can cause problems.

High-level repeaters, such as

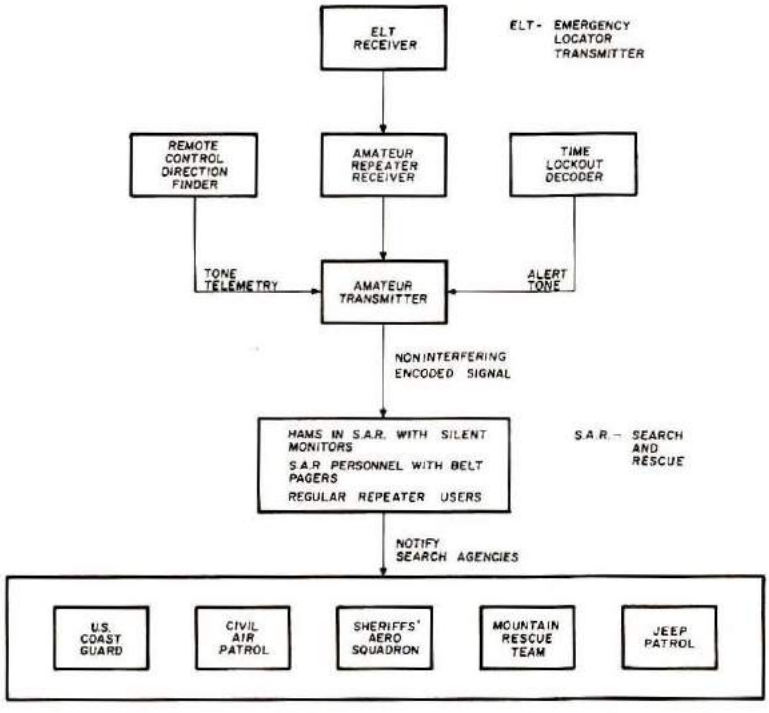
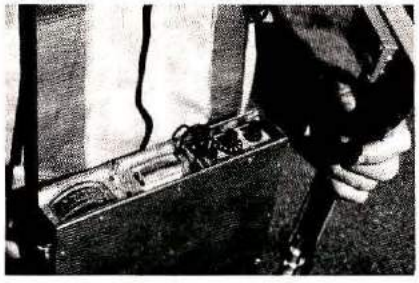


Fig. 14. Relationship between amateur radio and search agencies. This interface is now operating in many parts of the country.



Close-up of the "tummy toter," which is carried by a strap around the neck. It contains the portable 2-meter receiver and DF unit. The box is made of copper-clad steel for isolation.

those on the mountains of the West Coast, have coverage of many hundreds of square miles. Some repeaters are located in areas that have many line-of-sight airports. So the lockout time must be selected to avoid additive decoding from tests made at these airports — again, to avoid false alarms.

Fig. 12 shows a block diagram of a tone-alert, lockout decoder system that is effective during normal repeater up time. A tone oscillator can be turned on for a short time, or it can remain on continuously. The tone can be low level so that normal repeater traffic won't be interrupted. The tone can be in the subaudible range, so that only SAR people with decoders will be aware of its existence. On the other hand, others may prefer an audible tone, so that all users will be aware of its existence and can participate without decoders. For this reason, many prefer that all participants can hear a tone at, say, 2000 Hz at low level. Some repeaters have rebroadcast the actual downswept ELT tone, but this becomes annoying to repeater users and is difficult to adapt to an inexpensive, automatic callup scheme.

Other circuitry for enhancing repeater participation in SAR activities has been developed by the Happy Flyers, such as an automatic key and alert system, an audio command for 121.5-MHz receivers, and a silent monitor, which can be used as the tone oscillator as well as the command decoder. These circuits are inexpensive to build and information is available from Hart, WB6CQW, if you're interested.

Fig. 13 depicts an SAR-amateur repeater link using interface systems developed by the Happy Flyers. This system is presently operating in San Jose, California. An override is provided for jammer hunting.

An ELT signal from a downed aircraft is received by the amateur 2-meter repeater, which has a receiver tuned to 121.5 MHz. The ELT signal is rebroadcast to a remote link some distance away. Communications between the SAR team occur through an auto-dial link between the SAR base and the repeater. Bearing information is passed to the SAR team, again through the amateur repeater station, and rescue is on the way.

An overview of how the Happy Flyers have designed an effective search and rescue scheme, using amateur radio, is shown in **Fig. 14**. Credit for this illustration goes to Paul Hower, WA6GDC, the International Vice Commander of the Happy Flyers organization. It shows the elements of a team-coordinated organization of dedicated amateur-radio operators interested in helping people. It works; it has saved lives; it shows what hams can do.

Paramedic relay system

Fig. 15 shows another aspect of the work being done by the Happy Flyers. An airborne voice-operated relay system (audio coupled) relays information from a paramedic through his transceiver (operating at 47 MHz). The signal is relayed through an amateur 2-meter repeater to appropriate circuitry at a hospital. At the hospital, full amateur facilities are available: low-band phone patches for medical advice regarding burn treatment, surgery and related needs.

The hardware for the paramedic relay system is being built by amateurs. The system is designed for use in catastrophic incidents, such as a major earthquake.

Help is needed

The Happy Flyers welcomes ideas and suggestions from hams interested in perpetuating the basic premise of the organization: helping others. If you have any ideas about improving existing methods, or if you would like to know more about the many facets of this part of ham radio, feel free to write to Hart, WB6CQW, who will be happy to provide literature. The possibilities are endless for an improved image of amateur radio in the public eye. Let's hear from you! **HRH**

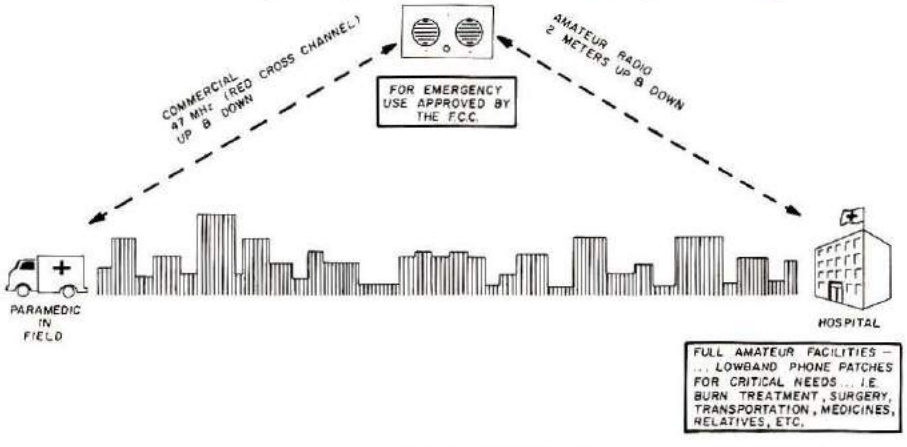

COMMERCIAL 47 MHz (RED CROSS CHANNEL) UP 8 DOWN
FOR EMERGENCY USE APPROVED BY THE F.C.C.
AMATEUR RADIO 2 METERS UP 8 DOWN
PARAMEDIC IN FIELD
HOSPITAL
FULL AMATEUR FACILITIES — .. LOWBAND PHONE PATCHES FOR CRITICAL NEEDS .. I.E. BURN TREATMENT, SURGERY, TRANSPORTATION, MEDICINES, RELATIVES, ETC.

Fig. 15. An airborne, voice-operated (audio coupled) relay system using amateur repeaters for communications between paramedics and a hospital. Such a system is designed for national emergencies.